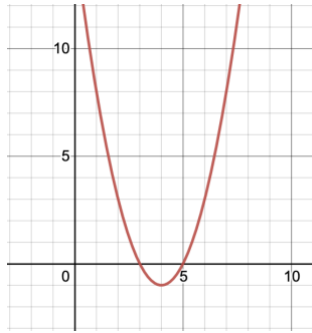


## 11. Shivam

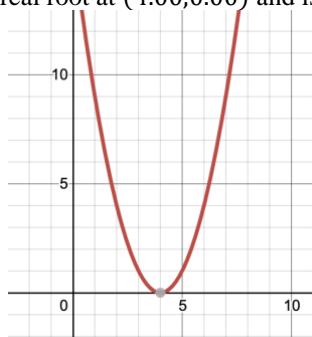
**Program Name:** Shivam.java

**Input File:** shivam.dat

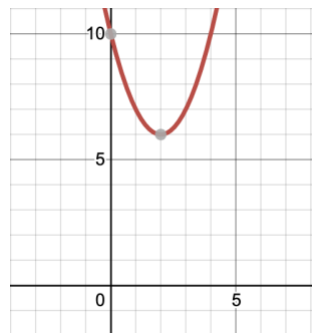
In Shivam's Algebra I class, Shivam's teacher just taught his class about quadratic functions. A quadratic function is any function that can be written in the form:  $f(x) = ax^2 + bx + c$  where  $x$  represents an unknown variable, the coefficients of the function are  $a$ ,  $b$ , and  $c$ , and  $a \neq 0$ . When graphed on the  $xy$  plane, quadratics are known for their "U" shaped appearance. For example, the function  $f(x) = x^2 - 8x + 15$  is graphed below:



Where the function intersects the  $x$  axis, of the  $xy$  plane, is known as the function's root(s). In the above example, the function has two real roots, one at (3.00,0.00) and another at (5.00,0.00). Not all quadratics have two real roots, though. For example, the function  $f(x) = x^2 - 8x + 16$  only has one real root at (4.00,0.00) and is graphed below:



Some quadratics have no real roots meaning their graph does not intersect the  $x$  axis at all. For example, the function  $f(x) = x^2 - 4x + 10$ , which is graphed below, shows an example of a quadratic that doesn't intersect the  $x$  axis at all.



Shivam needs your help writing a program that can read in a quadratic function  $f(x)$ , determine the number of roots, and where those roots are. Can you help him with this?

*Continued next page...*

*Shivam, continued*

**Input:** The input will consist of an integer  $F$ , the number of functions.  $F$  will be in the range of  $[1,20]$ . The following  $F$  lines will each contain a single function  $f(x)$  of the form  $f(x) = ax^2 + bx + c$ . There will be no spaces in the function input. For this program, the caret operator (^) will be used for exponents and not the xor operator.  $a$  will be in range of  $[-100,0) \cup (0,100]$ ,  $b$  and  $c$  will be in range  $[-100,100]$ .  $a$ ,  $b$ , and  $c$  are all guaranteed to be integers, but  $b$  and/or  $c$  are not guaranteed to be present in the function input. For example, the function  $f(x) = 4x^2 + 8$  is a legal input in which only coefficients  $a$  and  $c$  are present.

**Output:** For functions with two real roots, you are to output "Function #: There are two real roots at (ROOT1\_X,ROOT1\_Y) and (ROOT2\_X,ROOT2\_Y)." Roots should be displayed in ascending order according to the  $x$  component and rounded to two decimal places. For functions with one real root, you are to output "Function #: There is one real root at (ROOT1\_X,ROOT1\_Y)." The root should be rounded to two decimal places. For functions with no real roots, you are to output "Function #: There are no real roots to the function."

**Sample input:**

```
9
f(x)=x^2-8x+15
f(x)=x^2-8x+16
f(x)=x^2-4x+10
f(x)=-23x^2-25x
f(x)=4x^2+8
f(x)=-78x^2+32x+6
f(x)=-89x^2+6
f(x)=3x^2+54
f(x)=x^2
```

**Sample output:**

```
Function 1: There are two real roots at (3.00,0.00) and (5.00,0.00).
Function 2: There is one real root at (4.00,0.00).
Function 3: There are no real roots to the function.
Function 4: There are two real roots at (-1.09,0.00) and (0.00,0.00).
Function 5: There are no real roots to the function.
Function 6: There are two real roots at (-0.14,0.00) and (0.55,0.00).
Function 7: There are two real roots at (-0.26,0.00) and (0.26,0.00).
Function 8: There are no real roots to the function.
Function 9: There is one real root at (0.00,0.00).
```